FORAGE SUPPLEMENTS : NUTRITIONAL SIGNIFICANCE AND UTILISATION FOR DRAUGHT, MEAT AND MILK PRODUCTION IN BUFFALOES

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ABSTRACT

Constraints to inadequate dietary nutrients are discussed in the context of strategies for expanding the utilisation of a variety of forage supplements for draught power, meat and milk production in buffaloes. Good examples of these forages are berseem (*Trifolium alexandrinum*), cassava leaves (*Manihot esculenta* Crantz), gliricidia (*Gliricidia maculata*), leucaena (*Leucaena leucocephala*), water hyacinth (*Eichornia crassipes*), groundnut (*Arachis hypogaea*) and sweet potato (*Ipomoea batatas*) vines. These provide valuable supplemental nitrogen, energy, minerals and vitamins especially for diets based on low quality lignocellulosic roughage feeds such as cereal straws and sorghum stover. The resulting increased availability of nutrients enables a shift from sub-maintenance to production status. The review of results of forage utilisation indicates definite improved performance and economic benefits due to the reduced cost of feeding. In terms of practical application, 30-50% of supplementary forages on DM basis or 0.9%-1.5% levels as % of live weight are suitable. The results further suggest good opportunities for more vigorous and expanded use of these forages in research and development programmes that can take advantage of increased net metabolisable energy availability and maximum feed proteins escaping rumen degradation, as well as reducing the effects of toxic or deleterious principals. Innovative feeding systems involving green forage supplements are necessary that are demonstrably as efficient and more economic, than feeding concentrates. These approaches provide for more efficient use of available scarce resources on small farms. More particularly, the strategies together are likely to make a significant impact on increased productivity (draught power, meat and milk) and socio-economic contribution by buffaloes in Asia.

INTRODUCTION

The feeding patterns of milch and swamp buffaloes reflect a combination of their inherent attributes to utilise the available feeds, and response to management systems whose objective is to maximise productivity in terms of draught power, meat and milk production. An important feature concerning their feeding and nutrition is that between genotypes, the swamp type spends a large part of the adult life subsisting on very low planes of nutrition. These include wayside and rough grazing and subsistence especially on a variety of fibrous lignocellulosic materials such as cereal straws, stovers, sugarcane tops and bagasse.

Within the preponderence of small farms systems which combine animals including buffaloes with mixed cropping, mainly cereals like rice and wheat, characteristic of many parts of Asia, the swamp type is only used for approximately 30-50 days per year. During this time, animals are used for two ploughings and two raking/levelling operations, once or twice alone or in a pair. The duration increases in situations where cultivation is extended to include other annual and perennial crops, and in one or more other farm operations such as threshing, haulage and transportation. Beyond their intensive use during periods of land preparation, when they are especially well fed, swamp buffaloes are essentially on a maintenance regime, subsisting on low quality roughages for the rest of the year. By comparison, milch buffaloes enjoy a longer period of adequate feeding and nutrition consistent with a longer lactation period, higher nutrient demands of lactation and milk production.

An important attribute that is closely associated with low quality fibrous feeds, is their ability to make more efficient use of coarse roughage materials such as cereal straws, much more than cattle. Recent experiments in Australia (Kennedy et al., 1987a; 1987b; McSweeney and Kennedy, 1987) suggest that the advantages the swamp buffalo might have over cattle are associated with an increased recycling mechanism of urea from the blood to the rumen, higher rates of non-ammonia nitrogen, longer rumination times and faster rate of passage due to the force of fore-stomach contractions. The studies also confirm the point that swamp buffaloes consistently utilise dietary nitrogen more efficiently than cattle (Moran, 1983; Devendra, 1985a) to meet both maintenance and production requirements.

Outside of the period from the time of cultivation and planting through to harvesting, swamp buffaloes subsist almost exclusively on cereal straws (Doyle et al., 1986), often coinciding with regular prolonged dry seasons where the feed resources are depleted, and rice or wheat straws are the most important daily fodder resources available. This is seen regularly in the northern parts of Pakistan, parts of Gujarat and Rajasthan in India and Bangladesh (Verma and Jackson, 1984), the dry zone of Sri Lanka, north and north-eastern Thailand (Yano, 1984; Khajarern and Khajarern, 1985) northern Malaysia, parts of Indonesia and Philippines.

Low levels of nutrition and subsistence on cereal straws, manifest in serious deleterious effects on age at first calving, inter-calving intervals and prolongation of the non-productive life. Additionally, the degree of wastage and subsequent effects on performance of the progeny are enormous. This is inevitable since poor quality roughages cannot supply anything more than the basic nutrient needs for maintenance, which in such situations account for a large proportion of the total energy requirements of the animals. This justifies improvements to feeding systems that make available more nutrients. Following the harvest however, the buffaloes graze the stubble, paddy bunds, fresh regrowth of grasses and on weeds until the next cultivation cycle.

Taking cognisance of the traditional feeding and management systems, several alternative strategies have been pursued with the objective of increasing nutrient supply and improve current feeding systems to increase the supply of draught power, meat and milk production. Foremost in these initiatives are a variety of chemical pretreatments which have been used (Jackson, 1977; Ibrahim, 1983; Sundstol, 1984; Doyle and Pearce, 1985), among which urea treatment has been the most widely used in most countries. These have resulted in an increase in intake, digestibility or even both (Ibrahim et al., 1984), occassional growth (Perdok et al., 1982; Verma, 1983) and milk production (Davis, 1983) responses. The other successful development is the use of urea-molasses block licks in India (Kunju, 1986).

The inclusion of supplementary green forages especially for feeding systems based on fibrous low quality roughages represents an alternative strategy which merits research and development attention. This approach has enormous potential and is one which can make a significant impact on improved and economic feeding systems for buffaloes. This article focusses on the nutritional significance of these forages, and their potential value in the development of economic feeding systems for buffaloes.

CROP RESIDUES AND GREEN FORAGES

Table 1 identifies the most common crop residues and green forages that are used as supplements in feeding systems for buffaloes. These forages are particularly valuable in increasing the supply of dietary nutrients. Under adverse dry conditions such as in draught, some of these fodders like leucaena form the major component of the diet. The more commonly used such feeds among these in many parts of Asia are _inter alia_ cassava leaves (_Manihot esculenta_ Crantz), leucaena forage (_Leucaena leucocephala_), gliricidia (G. _maculata_) and sesbania (_Sesbania grandiflora_). In India, Pakistan and Egypt, berseem (_Trifolium alexandrinum_) is very widely used to feed buffaloes and cattle. Many of these crop residues and green forages are widely used as protein and energy sources. Included among the various types of roughages, crop residues and green forages are many non-conventional feeds (Devendra, 1985b; 1987). The efficiency with which these feedstuffs are utilised is dictated by the characteristics of the feeds, inherent limitations, knowledge on how they are digested in the alimentary system and type of feeding system (Devendra, 1985c).

There are a number of advantages concerning the use of these forages for ruminants on small farms in Asia (Devendra, 1984). In Thailand, Wanapat (1986) has reported several studies where dietary forages have promoted positive responses in swamp buffaloes. The advantages of dietary forages include _inter alia_ availability in the farms, accessibility, provision of variety in the diet, source of dietary nitrogen (N), energy, minerals especially S, vitamins, laxative influence on the alimentary system, reduction in the requirements for purchased concentrates and reduced cost of feeding. Leucaena for example, can withstand dehydration, supply N and a valuable source of sulphur for the rumen bacteria. Additionally, leucaena is also valued for multi-purpose use in fence lines and as a fuel.

The beneficial effects of supplementary forages are dependent essentially on the quality of the forage and the proportion of stems and even pods. These components explain why in some experiments supplementing leucaena for example, had little effect on diet digestibility even when it comprised a significant portion of the diet (Devendra, 1983; Moran et al., 1983; Semali and Mathius, 1984; Sitorus, et al., 1985). Feeding leucaena leaves compared to leucaena leaves plus stems plus pods in balance trials with sheep, gave best N retention and mineral retentions for the former (Devendra, 1983). For best performance therefore, leafy material need to be fed in optimum amounts, for which forage quality is important in ensuring the supply of energy, N, minerals and vitamins.

ENERGY AND NITROGEN SUPPLY

Energy and protein supply represent the principal limitations inherent in diets based on low quality, fibrous, lignocellulosic roughage feeds. These limitations, together with sheer bulk, form the basis for considering type, extent and cost of supplementation in appropriate feeding systems for buffaloes.

Theoretical calculations (Doyle et al., 1986) demonstrate this point. For buffaloes in the 200-400kg live weight range, the requirements of digestible organic matter (DOM) are between 1.4-2.9kg, which do not meet the energy requirements for maintenance suggested by Kearl (1982).

Thus for example, the dry matter intake (DMI) data (kg/100 kg live weight) for four rates of substitution with gliricidia (G. maculata) of bulls based on results in Sri Lanka (Doyle et al., 1986) were as follows:

Untreated rice straw + gliricidia : 2.7, 3.0, 3.0 and 3.3 kg/100 kg LW

Urea-treated rice straw + gliricidia : 3.2, 3.1, 3.4 and 2.8 kg/100 kg LW

The DMI data when converted to ME values (DMI x DM digestibility x 0.81) and an average gross energy content of 18 MJ/kg gave the following corresponding ME intake values :

Untreated rice straw + gliricidia: 18.5, 20.1, 21.5 and 26.5 MJ ME/100 kg LW

Urea-treated rice straw + gliricidia: 19.2, 22.3, 28.5 and 28.8 MJ ME/100 kg LW

Gliricidia supplementation of untreated rice straw reduced the effect of live weight loss up to a substitution rate (decline in rice straw intake ÷ increase in the amount of supplement given) of 49, and increased live weight gain (10 g/day) at the higher rate of 55. With urea-treated rice straw and with a substitution rate of up to 44, the live weight increased to 130 g/day, reflecting the combined advantages of the improved straw and gliricidia supplementation.

Supplementary N is equally essential since the crude protein contents are critically low in low quality roughages. Leibholz and Kellaway (1984) have estimated that the minimum crude protein content of a poor quality diet with a digestible organic matter (DOM) in dry matter value of 50% would be 6.1-7.4%. It is also generally agreed that levels of about 70mg ammonia N/l are required for optimal rumen microbial activity (Satter and Raffler, 1977). Most poor quality roughages, have inherently much lower DOM and much lower levels of crude protein, and will therefore necessitate nitrogen supplementation. Bamualim et al., (1984) observed that supplementation with leucaena at levels of 30% DMI not only resulted in a significant increase in digestibile organic matter intake (DOMI), but also doubled the quantities of feed protein escaping the rumen. Among minerals, sodium is usually deficient and also needs supplementation.

With specific reference to draught, it has recently been suggested that this is associated with improved digestive function (Ffoulkes _et al._, 1986). This implies that buffaloes at work may well be making the most efficient use of low quality fibrous feeds. The finding supports a similar observation in working horses (Orton _et al._, 1983), and longer retention time of digesta is implicated. It has also been suggested that this may be due to more efficient digestion in the small intestine because of hormonal stimulations of gastric enzymes as a response to changes in concentration of nutrients in the blood.

The significance of an increased supply of dietary nutrients to product output has been demonstrated in a number of studies. The sections following present a comprehensive review of the findings with respect to berseem, cassava, gliricidia, leucaena, water hyacinth and other forages.

UTILISATION

(1) _Berseem_ (_T. alexandrinum_)

Several studies have demonstrated the use of berseem in the diet of buffaloes. Saran and Jackson (1967) completely replaced the concentrate mixture with berseem, and Chauhan and Chopra (1984) the concentrate mixture with 33-66% berseem on the basis of digestible organic matter; both results reported that milk composition was unaffected. Chauhan (1986) replaced 80-100% of the concentrate mixture with berseem hay on the basis of _in vitro_ digestible organic matter in lactating buffaloes over 82 days. There were no treatment differences in milk yield and composition, however, the feed cost per day per animal was reduced by 22% with the 100% inclusion of berseem (Table 2). The addition of berseem as silage and hay to rice straw, dry mature grass and sorghum straw has been shown to improve the digestibility of the coarse roughages fed to buffaloes (Singh *et al.*, 1986).

(2) Cassava (*M. esculenta* Crantz)

The beneficial effects of feeding buffaloes with wilted cassava leaves and stems inclusion at 1, 2 or 3kg/head/day with untreated rice straw *ad libitum* have been studied in Indonesia. Increasing intakes of cassava leaves progressively reduced the voluntary consumption of rice straw significantly ($P < 0.05$). However, the total dry matter intake was not different in the two groups.

The increase in cassava leaves intake was reflected in progressively increasing rates of significant live weight gains ($P < 0.05$) due to increased dry matter intake and digestibility. The protein intakes increased from 0.65 kg/day to a 0.81 and 1.04 kg/day for the three levels of cassava leaf feeding.

In Thailand, supplemented dried cassava leaves fed at 1 kg/head/day with rice straw reduced live weight loss (Hutanuwatr, 1980). On the other hand, supplementing 200g of dried cassava leaf meal with urea-treated rice straw diets increased live weight gain in buffalo steers significantly compared to feeding urea treated rice straw alone (Table 3). It would have been useful to have also assessed in the same experiment, the effect of feeding cassava leaves with the untreated rice straw diet and the comparative responses in economic terms.

(3) Gliricidia (*G. maculata*)

The utilisation of supplemented gliricidia (*G. maculenta*) and cassava leaves (M. esculenta Crantz) has been studied in Sri Lanka. Perdok et al., (1982) reported results indicating that supplements of 1600g gliricidia (DM/cow/day) increased milk and milk fat yields. With coconut cake supplementation, both milk yield and milk fat yield were significantly increased ($P < 0.05$), whereas gliricidia and leucaena leaves did not affect both components. A subsequent study indicated that gliricidia or leucaena supplementation were comparable in milk yield. Supplementing the treated straw with gliricidia or leucaena in addition to coconut cake did not have any significant effect on milk yield and milk fat yields. An economic analysis of the profit margins due to treatments indicated (Table 4) that supplements of tree legumes marginally improved milk and milk fat yields but was considerably improved by supplementation with 7kg coconut cake.

(4) Leucaena (L. leucocephala)

Leucaena leaves and forages (leaves + stems + pods) have been the most widely used of the green feeds in feeding systems for buffaloes; their beneficial inclusion in the diet and for the ASEAN region has been reviewed (Devendra, 1986). The consistent conclusion that emerges is the fact that leucaena supplementation was advantageous for meat and milk production and draught capacity.

In Thailand, the effects of breed (Murrah x swamp and swamp), feed supplement (with or without) on draught (work or no work) was studied over six months. The concentrate supplement consisted of cassava chips and dried leucaena leaf in the ratio 3 : 1 for 1.5kg/head/day. The animals without supplements were fed on silage.

Over the first four months prior to the assessment of draught capacity in both breeds, supplementation as one would expect, significantly stimulated growth rate (Table 5). Concerning working ability, Thai swamp buffaloes ploughed more than the crossbred Murrah, and supplementation increased the area ploughed, but its effects and differences between breeds were not significant. No differences were also found in the speed of ploughing between breeds and due to supplementation. However, there was a tendency towards a faster speed of ploughing for both breeds when supplements were fed (Table 6).

Also in Thailand Snitwong et al., (1983) fed up to 60% leucaena leaf meal in combination with 1% urea and 34% cassava chips to buffaloes and recorded a daily gain of 0.48/head. The negative results with DHP (3-dehydroxy-H-pyridone) suggested that buffaloes were able to tolerate high levels of dietary leucaena leaf meal (Table 7).

Leucaena forage has also been used in several studies with buffaloes in India in which they have been shown to have beneficial effects (Kapoor et al., 1983; Dharmaraj et al., 1985; Akbar and Gupta, 1985).

Further work in Thailand, feeding supplemental leucaena leaf to dehydrated sugarcane tops fed as the basic roughage source significantly improved ($P < 0.05$) live weight gain (Snitwong et al., 1983; Wongsrikeao and Wanapat, 1985). The latter also showed that the highest live weight gain of 444g/head/day was recorded in buffalo steers with urea-treated rice straw and leucaena leaf meal. Leucaena leaf meal either fed alone or when supplemented with water hyacinth improved organic matter and crude protein digestibility (Sriwattanasombat and Wanapat, 1985).

Recently, buffaloes fed a 95.5 mixture of rice straw and leucaena leaf together with a mineral mixture showed similar intakes and OM digestibility compared to cattle. Digestion of cell walls was reduced in buffaloes due to faster rate of passage of digesta from the rumen. Twice as much urea was recycled from the blood to the rumen of buffaloes, associated with higher concentrations of blood urea and rumen ammonia and flow on non-ammonia nitrogen into the intestines (Kennedy *et al*., 1987).

(5) Water hyacinth (*Eichornia crassipes*)

Water hyacinth (*E. crassipes*) has been fed extensively in a series of studies in Thailand (Wanapat, 1986). The feeding value of this forage is similar to that of leucaena forage when fed in a urea-treated rice straw diet (Sriwattanasombat and Wanapat, 1985). Feeding water hyacinth to urea treated rice straw significantly increased live weight gain and also improved feed efficiency.

(6) Other forages

There are several other examples of green forages that have been used as supplements with crop residues. These include the use of green oats (*Avena sativa*) and green maize (*Zea mays*) to Murrah buffalo heifers (Mallikarjunappa and Mudgal, 1984) and mesquite (*Prosopis juliflora*). In rice-based systems where buffaloes thrive, other crop residues that are potentially important are broad bean (*Vicia faba*), mung bean (*Vigna radiata*), cowpea (*V. unguilata*) and lablab (*Lablab purpureus*). These examples are by no means complete since the range of availability of the green forages, including grasses, is enormous. These supplements are often fed in conjunction with bulky dry roughages which are enormous in Asia.

ECONOMIC IMPLICATIONS

One important objective in improved feeding systems associated with increased production responses in terms of meat and milk and draught power, is demonstration that the value of the response has a greater monetary value due to the inclusion of supplemental forages. This objective is mediated by increased rates of digestion of the fibrous feeds, reduced cost of feeding and improved nutritional management. The strategy is especially important when weighed against the scarce resources available in small farms, and limited funds to purchase concentrate feeds.

Several studies have demonstrated beneficial effects, due to the inclusion of proteinaceous forages, often to replace the protein component in the diet which are often purchased at high cost. Table 8 summarises the results from nine studies, five in India, two in Thailand and one each in Sri Lanka and the Philippines. Earlier studies in India on lactating animals also showed the benefits of forages such as berseem and lucerne (Daniel _et al_., 1967; Saran and Jackson, 1967; Jackson and Gupta, 1971; Patel and Shukla, 1973). The beneficial effects of supplementary leucaena have also been reported for growing (Cheva-Isarakul and Potikanond, 1985) and lactating (Promma _et at_., 1985) cattle also in Thailand.

ANTI-METABOLITIES

The use of various proteinaceous forage supplements is not without problems. Various types of anti-metabolities, toxic or deleterious factors exist. Table 9 tabulates the types and contents present.

In nutritional terms, the presence of these anti-metabolities is not always a disadvantage or a limitation. Tannins are a case in point. Although they are known to be toxic to microorganisms and animals, there is no evidence that forage tannins are detrimental to ruminants, although they have been shown to reduce protein digestibility (McLeod, 1974). Tannins are found in a number of feeds and belong to the class of polyphenols and comprise both condensed and hydrolysable types. The former is the more common and are found in leaves and stems, and the latter in fruit pods and seeds.

It has recently been suggested that low concentrations of condensed tannins (20 - 30g/kg DM) found for example in Lotus pedunculatus improve nutrient utilisation by ruminants, principally by reducing forage protein degradation in the rumen (Barry and Blaney, 1987). Since protein solubility and rate of flow of digesta influence the quality of dietary protein for post-rumen digestion (Annison, 1956; Kempton et al., 1977), the magnitude of solubility of proteins in the rumen will reflect quality. Thus, it has been shown in Sri Lanka that in terms of solubility of proteins in the rumen and acid-pepsin protein at 8 hr (to stimulate post-rumen digestion), the lowest solubility was recorded by gliricidia leaf, followed by leucaena leaf meal and then cassava leaf meal (Jayasuriya et al., 1982).

PRACTICAL APPLICATION

The review on the inclusion of dietary proteinacious supplementary forages, especially legumes ones, and their utilisation clearly demonstrate distinct benefits. In terms of practical application, the following pointers are suggested :

- Optimum dietary level on DM basis : 30 - 50%
- As % of live weight : 0.9 - 1.5%

CONCLUSION

Supplementary forages have a potentially important role in improving the efficiency of prevailing feeding systems and increasing draught capacity, meat and milk output in buffaloes. Demonstration of these benefits, including economic advantages, justifies expanded use of dietary forages. Research and development programmes to achieve both objectives, currently inadequate, need to address their utilisation more widely and vigorously as well as pursue quantitative aspects of forage production, utilisation of optimum proportions of leaves to stems, the extent of the degradation of dietary proteins, nutritional limitations in the feeds and responses in buffaloes. The efforts together are likely to make a significant impact on improved feeding systems and the present level of performance for increasing the productivity and socio-economic contribution from buffaloes throughout Asia.

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TABLE 1

TYPES AND NUTRITIONAL CHARACTERISTCS OF PRINCIPAL CROP RESIDUES AND FORAGES

Feed source	Moisture (%)	Crude protein+ (%)	Crude fibre (%)	Metabolisable energy (MJ/kg)
Crop residue				
Cassava leaves	23.8	23.6	24.6	9.2-11.1
Groundnut vines	28.7	13.7	24.1	8.0-8.4
Pigeon pea leaves	27.0	22.8	20.1	10.8-12.51
Sweet potato vines	16.0	13.3	17.2	10.8-12.5
Green forage				
Acacia leaves	30.1	21.2	21.4	3.2-6.4
Banana leaves	24.0	17.6	28.6	9.4-10.0
Berseem	21.4	23.2	24.4	9.7-12.8
Erythrina orientalis	14.2	32.9	24.2	12.6-13.6
Gliricidia leaves	24.8	26.7	18.7	4.4-7.0
Jackfruit	32.6	16.4	17.8	6.2-9.9
Leucaena				
-leaves	30.0	22.0	19.6	13.1-13.4
-leaves, stems and pods	30.1	17.4	30.5	7.1-10.4
Sesbania	24.2	28.4	18.9	8.7-8.9
Water hyacinth	6.4	14.8	26.4	9.5-11.7

+ N X 6.25

TABLE 2

EFFECT OF REPLACEMENT OF CONVENTIONAL CONCENTRATE MIXTURE WITH BERSEEM HAY ON MILK YIELD AND COMPOSITION IN LACTATING BUFFALOES

(Chauhan, 1986)

Particulars	Control	80% Berseem	100% Berseem
A) Milk yield			
Total milk yield (kg) for 84 days	712.18±13.76	717.50±19.69	757.40±27.20
Average milk yield (kg/day)	8.48±0.11	8.54±0.23	9.02±0.32
Total body weight gain or loss during 84 days	±8.70	±8.40	±9.50
Average DM intake (kg/100kg body weight) during 84 days	2.87±0.05	3.12*±0.04	3.12*±0.05
B) Milk constituents			
Total proteins	3.92	3.88	3.80
Casein	3.28	3.03	3.00
Fat	6.94	7.05	7.18
Lactose	4.75	4.80	4.95
Total solids	16.70	16.40	16.50
SNF	9.76	9.35	9.32

*Significant ($P \angle 0.05$)

TABLE 3

DRY MATTER INTAKE OF STRAW AND WEIGHT CHANGE BY WATER BUFFALO STEERS

(Wanapat, *et al*., 1983)

Item	Ration			±SEM
	URS	UTS	UTS+DCL	
Average body weight (kg)	259^{a}	248^{a}	252.7^{a}	3.3
Dry matter intake (kg/d)	4.77^{a}	6.14^{b}	5.52^{ab}	0.2
Dry matter intake (% of BW/d)	1.84^{a}	2.47^{b}	2.19^{ab}	0.1
Dry matter intake (g/kg $W^{.75}$/d)	75.1^{a}	98.1^{b}	88.7^{ab}	3.5
Weight change (g/d)	-383^{a}	136^{b}	182^{c}	18

URS - untreated rice straw

UTS - urea-treated (5%) rice straw

DCL - dried cassava leaf

abc - Values on the same row with different superscripts differ significantly ($P < 0.05$)

TABLE 4

THE EFFECT OF FEEDING UREA-AMMONIA TREATED STRAW WITH SUPPLEMENTS TO LACTATING SURTI BUFFALOES IN SRI LANKA (Perdok *et al*., 1983)

Parameter	TRS	TRS + G (212 CP)++	TRS + L (251 CP)	TRS + CC (191 CP)	TRS + G + CC (406 CP)	TRS + L + CC (448 CP)
		Treatment+				
Milk yield (kg/day)	2.41^{a}	2.60^{a}	2.73^{ab}	3.09^{ac}	3.18c	3.36^{c}
Milk fat yield (g/day)	221^{a}	242^{a}	238^{a}	311^{b}	319^{b}	325b
Milk fat percentage (%)	9.18	9.34	8.71	10.08	10.03	9.65
Margin over costs (S.L. Rs)	4.07	5.19	4.57	8.34	8.52	8.53

\+ TRS - Urea-ammonia treated rice straw; G - gliricidia; L - Leucaena; CC - Coconut cake

++ Amount of crude protein provided

abc Means on the same row with different superscripts differ significantly ($P < 0.05$)

TABLE 5

WEIGHT CHANGES AND AVERAGE DAILY GAINS OF BUFFALOES DURING THE FIRST FOUR MONTHS OF THE EXPERIMENTAL PERIOD

(Konta *et al.*, 1986)

Description	Murrah x Swamp Crossbred		Swamp Buffalo	
	NFS	FS	NFS	FS
Average initial wt (Kg)	307.25	282.88	278.00	288.75
Average final wt (Kg)	297.50	284.88	269.13	289.75
Average weight gain (Kg)	-9.75	2.00	-8.87	1.00
Average daily gain (g/hd/d)[1]	-108.3[a]	22.2[c]	-98.6[a]	11.1[b]

[1] Means on the same line with different letters, suggest significant difference ($P < 0.05$)

NFS = Non-feed supplement

FS = Feed supplement

TABLE 6

WORKING CAPACITY OF BUFFALOES (Konta *et al.*, 1986)

Description	Murrah x Swamp Crossbred		Swamp Buffalo	
	NFS	FS	NFS	FS
Area plowed (rai+/hd/hr)	0.23[a]	0.23[a]	0.24[b]	0.30[b]
Plowing speed (m/min)	40.71[a]	48.42[a]	43.86[a]	53.32[b]*

(+1 acre = 2½ rai)

NFS = Non-feed supplement

FS = Feed supplement

* Means on the same line with different letters, suggest significant difference (P ∠ 0.05)

TABLE 7

PERFORMANCE OF BUFFALOES FED ON RICE STRAW WITH LEUCAENA LEAF MEAL AND CONCENTRATE SUPPLEMENT

(Snitwong *et al.*, 1983)

Feed ingredients	Control	40% LM+	50% LM	60% LM
Cassava chips	47	45	43.5	34
Soybean cake	18	5	-	-
Leaf meal	0	40	50	60
Rice bran	20	-	-	-
Corn meal	15	9	5	5
Urea	-	1	1.5	1
Crude protein (%)	13.2	13.4	13.8	13.7
Mimosine (%)	0	1.28	1.60	1.92
Performance				
No. of buffaloes	5	5	5	5
Duration (days)	120	120	120	120
Initial wt. (kg)	317.3	316.9	342.6	326.5
Average daily gain (kg/head)	0.62	0.48	0.39	0.48
Feed intake (kg/head/day)	8.09	9.02	9.20	9.02
DHP++ test, urine	negative	negative	negative	negative
Weight of thyroid gland (g)	37	25	25	31

+ Leucaena leaf meal

++ 3 - dehydroxy - H pyridone

TABLE 8

RESULTS OF ECONOMIC BENEFITS OF FORAGE SUPPLEMENTS IN DIETS FOR BUFFALOES AND CATTLE

Feeding regime	Forage supplement	Species	Location	Response	Result	Reference
Wheat straw* + conc.	Lucerne + berseem	Buffaloes	India	Milk	Reduced cost /kg SCM milk	Gupta _et al_., (1983)
Concentrates	Berseem hay	Buffaloes	India	Milk	Reduced cost /kg milk	Chauhan and Chopra (1984)
Rice straw+	Gliricidia or Leucaena	Buffaloes	Sri Lanka	Milk	Increased margin over costs	Perdok _et al_., (1983)
Wheat straw* + conc	Leucaena	Calves	India	LW	Reduced cost /kg LW gain	Akbar and Gupta (1985)
Concentrates	Leucaena	Buffaloes	India	Milk	Reduced cost /kg FCM milk	Dharmaraj _et al_., (1985)
Oat silage + conc.	Berseem hay	Buffaloes	India	Milk	Reduced cost /kg milk	Chauhan (1986)
Rice straw++	Leucaena	Cattle	Thailand	LW gain	Reduced cost /kg LW gain	Cheva-Isarakul and Potikanond (1985)
Rice straw++	Leucaena	Cattle	Thailand	Milk	Reduced cost /kg milk	Promma _et al_., (1985)
Rice straw* + dried poultry litter + conc	Leucaena leaf meal	Cattle	Philippines	LW gained Milk	Reduced cost/ kg LW gain Reduced cost/ by milk	Trung _et al_., (1987)

* Untreated wheat straw
\+ Urea-treated rice straw
++Urea-treated or untreated rice straw

TABLE 9

EXAMPLES OF TOXIC PRINCIPALS IN THE MORE COMMON AGRO-INDUSTRIAL BY-PRODUCTS AND NON-CONVENTIONAL FEED RESOURCES

Type of feed	Toxic principal
Acacia leaves and pods	Cyanoglucosides, tannins and fluoroacetic acid
Banana waste, stems and leaves	Tannins
Cassava leaves, peeling and pomace	HCN (17.5 mg/100g in leaves)
Castor seed meal	Ricinoleic acid
Cocoa seed husks	Theobromine (Trace)
Coffee seed hulls, pulp	Caffeine and tannins (2.8% DM)
Cottonseed cake	Gossypol (0.05 - 0.20%)
Guar meal	Trypsin inhibitor and gum
Kapok	Cycloponopenoid acid
Mango seed kernel	Tannin (5-10%)
Neem seed cake	Tannin
Palm oil mill effluent	High ash (12-16% DM)
Rubber seed meal	HCN (9 mg/100g)
Sal seed meal	Tannin (6.2-13.7%)
Spent tea leaf	Tannin (12% DM)